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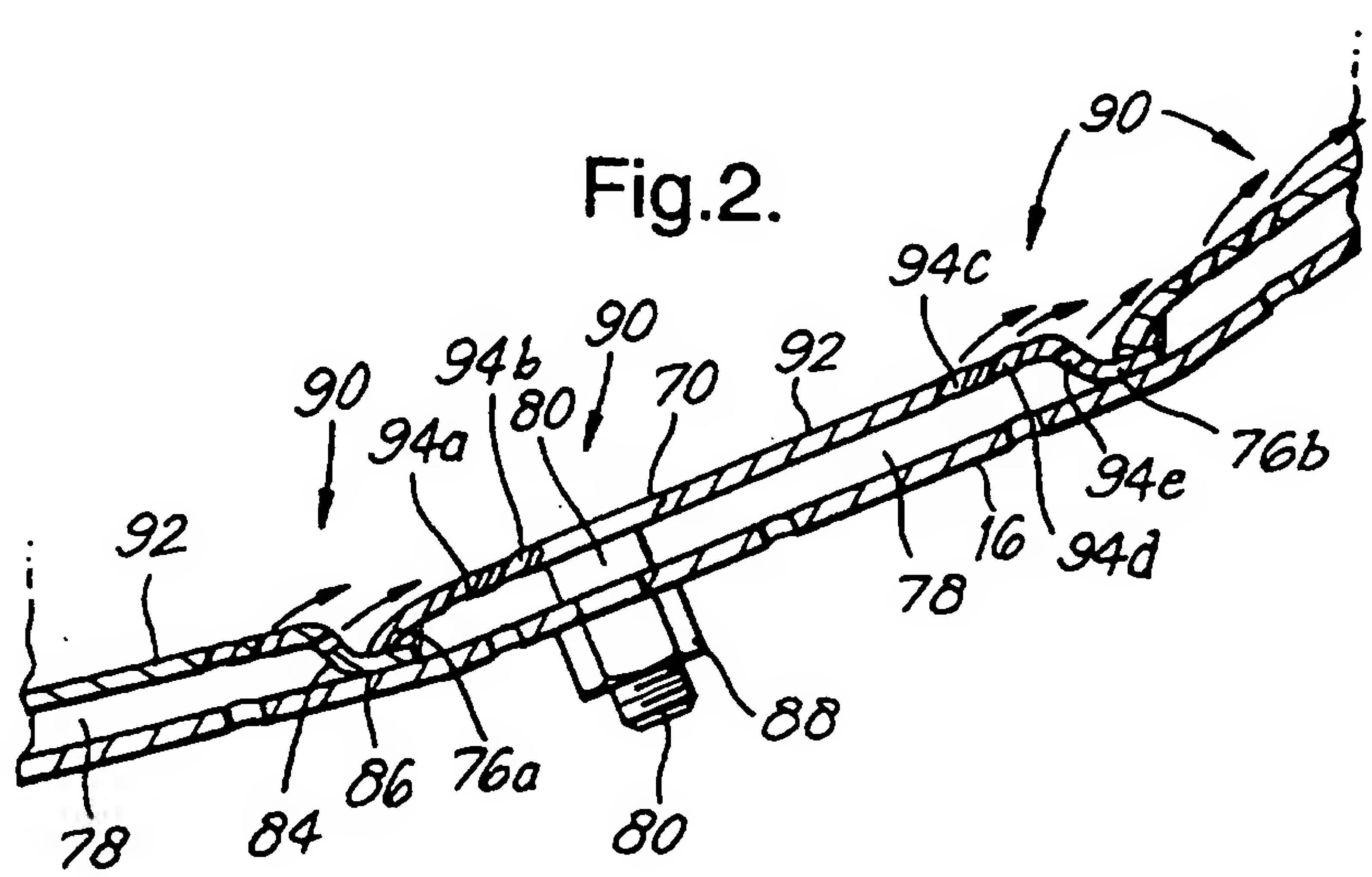
(54) **A cooling arrangement for heat resistant tiles in a gas turbine engine combustor**

(57) A plurality of heat resistant tiles 70 are provided which combine to form an internal liner around the walls of an annular combustor. In a first embodiment a plurality of tiles are arranged row by row in an overlapping relationship to form a fully annular shield around the inner and outer combustor walls. The tiles are provided with at least one row of effusion film cooling holes 94d, 94e to promote an effusion film flow across the exposed surface 92 of the tiles and the exposed edges of neighbouring tiles. The tiles also have holes 94a, 94b at their upstream ends to help cool their upstream edges. In a second embodiment the combustor includes a plurality of heatshield tiles which combine to form an annular heatshield around an upstream combustor bulkhead. In this embodiment the bulkhead tiles are provided with effusion film cooling holes which are disposed at the edge of the tiles to promote an effusion film flow onto the upstream edge of a first row of sidewall liner tiles. In a third embodiment the final row of sidewall tiles are similarly adapted to promote an effusion film flow across the exposed upstream edges of an array of nozzle guide vane platforms.

Fig.2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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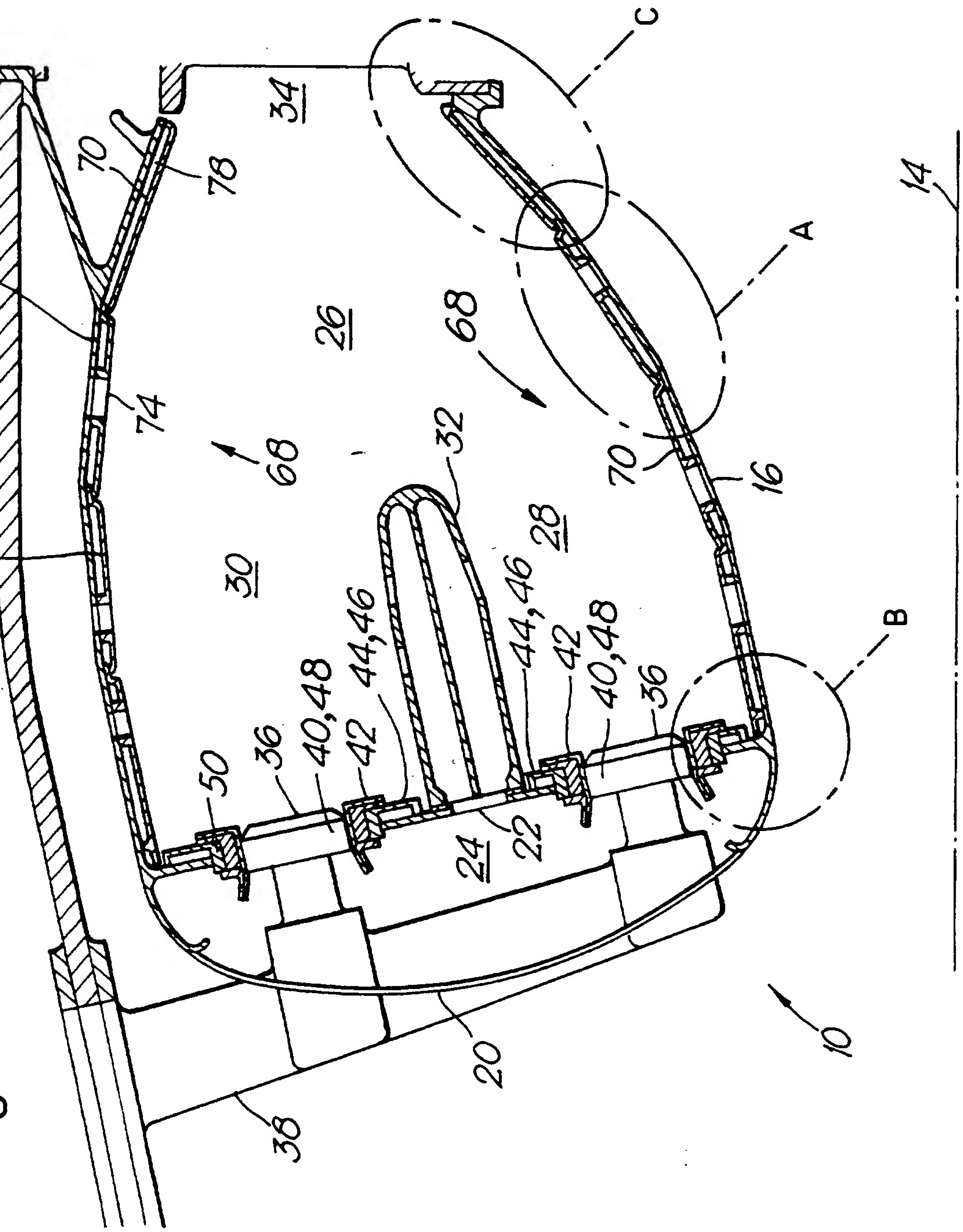
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68
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C
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40,48
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44,46
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38
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Fig.1.

Fig.2.

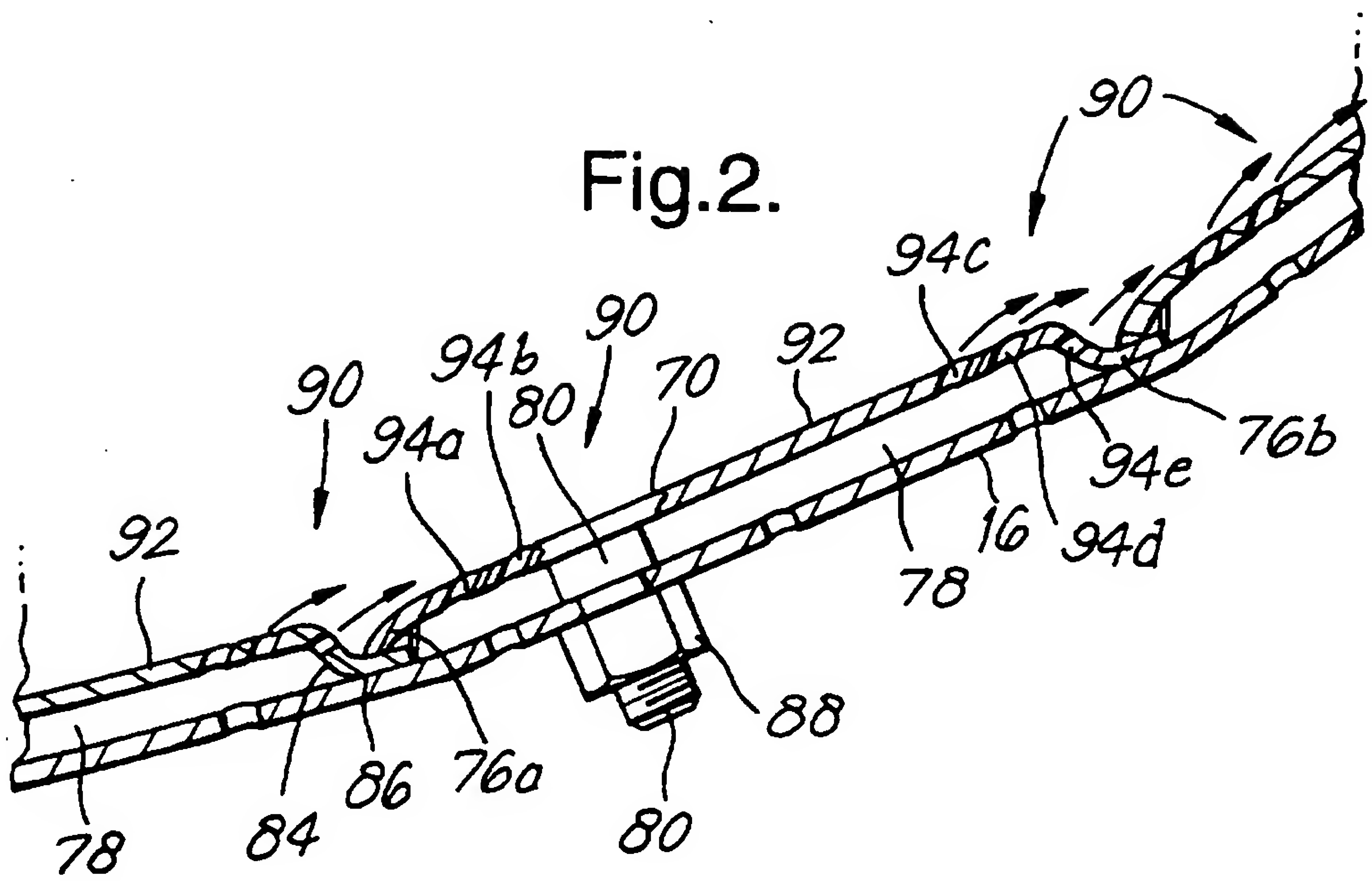
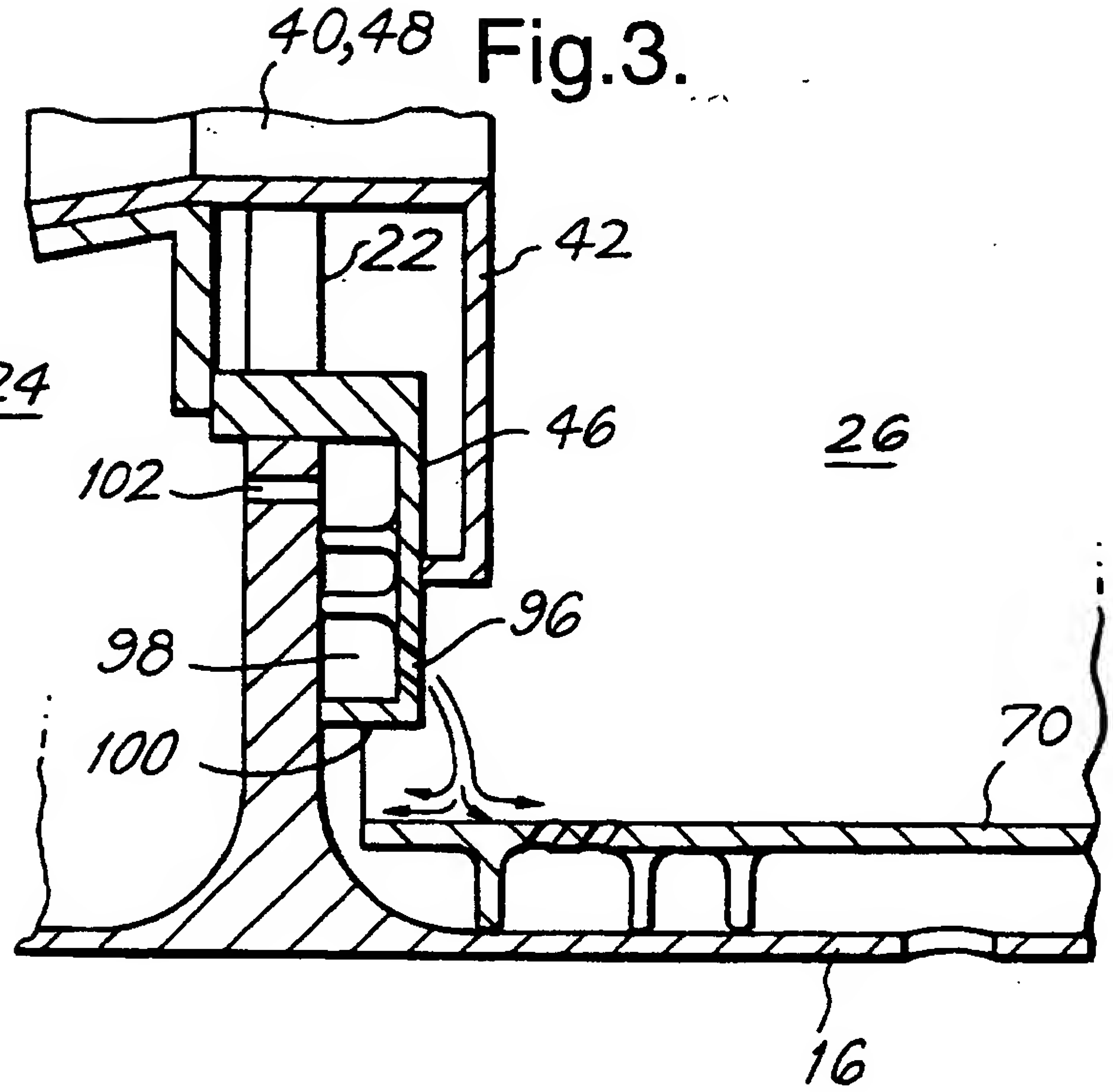


Fig.3.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24
46
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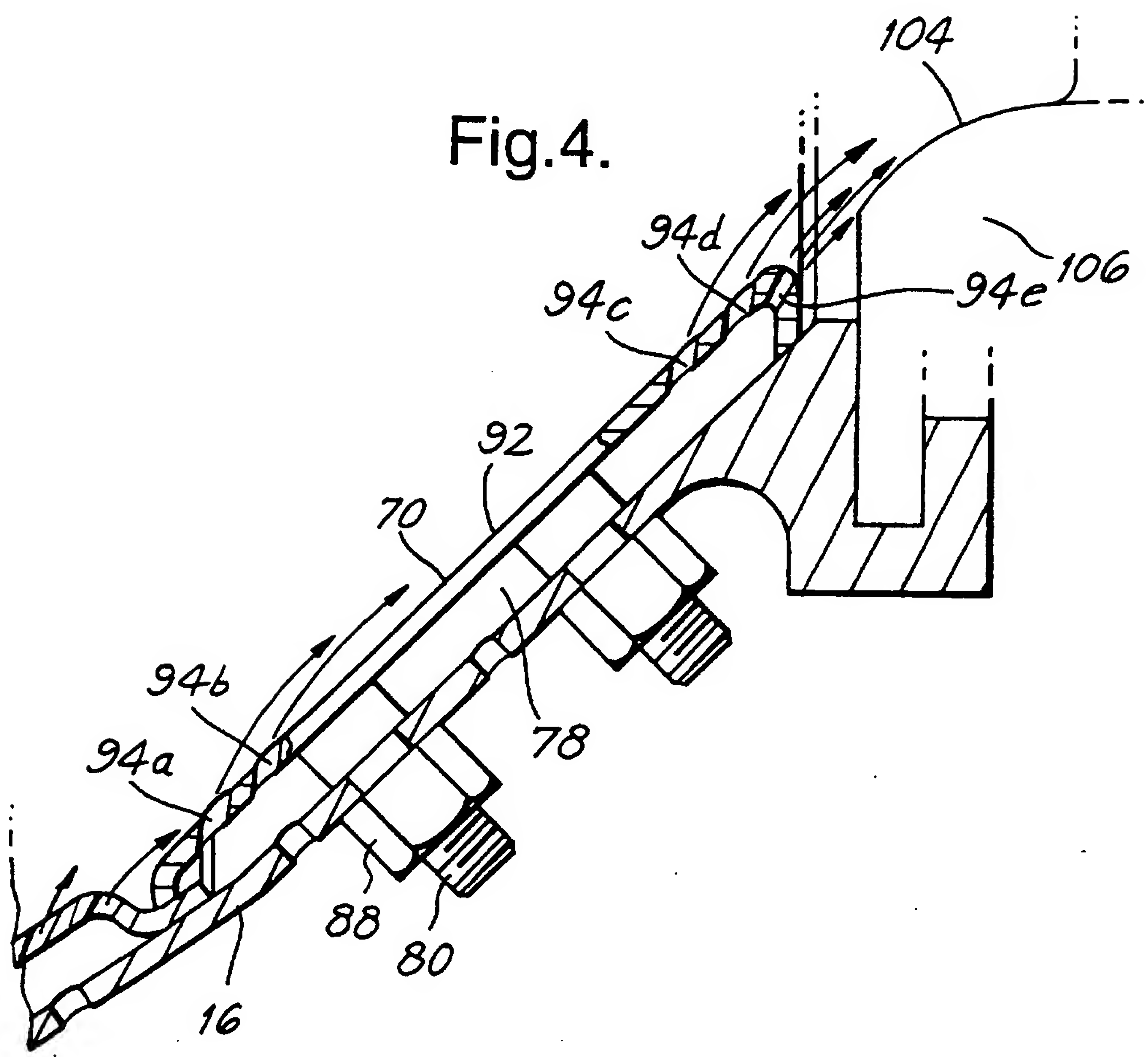
102
96
98
70
100
16

Fig.4.


104
94d
106
94c
94e
92
70
94b
78
94a
88
80
16

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A COOLING ARRANGEMENT FOR HEAT RESISTANT TILES IN A GAS TURBINE ENGINE COMBUSTOR

This invention relates to a cooling arrangement for heat resistant tiles in a gas turbine engine combustor. In particular the invention concerns an effusion cooling arrangement for heat resistant tiles which combine to form an internal liner around the walls of an annular combustor.

Modern gas turbine annular combustors are usually provided with an upstream endwall or bulkhead which extends radially between inner and outer combustor side-wall members to define an upstream plenum and a downstream combustion chamber. The bulkhead is usually provided with a plurality of circumferentially spaced apertures, each of which receives an air/fuel injection device for introducing a mixture of air and fuel into the combustion chamber during engine operation.

In order to protect the bulkhead from combustion temperatures it is often necessary to attach heatshield tiles to the bulkhead structure. In a known arrangement the bulkhead is protected by an annular array of segmented heatshield elements. The segments, which are each associated with one of the air/fuel injection devices, extend both radially towards the inner and outer extents of the bulkhead and circumferentially to abut adjacent segments. The air/fuel injection devices extend into the combustion chamber through corresponding apertures in the heatshield tiles. Each tile is spaced apart from the bulkhead so that a narrow cooling passage is defined between the components. In use cooling air is directed to these passages for tile cooling, and is exhausted through effusion film cooling holes formed in

the tile to provide a protective film over the exposed downstream surface.

In modern high temperature rise combustors there is a similar requirement to protect the inner and outer combustor sidewalls. Various cooling methods have been proposed including the use of cooling rings and the like formed in the combustor walls. These arrangements have been successful but in recent years there has been a move towards more efficient use of cooling air and to this end cooling arrangements using heat resistant tiles have been developed. In known arrangements the tiles are arranged in a contiguous row by row manner between the upstream combustor bulkhead and the downstream combustor exit. The tiles are spaced a short distance from the sidewalls in a similar manner to the bulkhead tiles to create a series of under tile cavities. Each cavity is adapted to receive a flow of cooling air, which, in use, discharges as a protective film, through film cooling holes, over the exposed tile surface. The cooling holes are provided over the majority of the tile surface, but not at the tile extremities where there is an absence of such holes for tile integrity purposes.

The major drawback with this type of arrangement is that a protective film is rarely achieved over the entire tile surface. This is partly due to the absence of film cooling holes at the tile edges, and also the tendency of the film to be drawn off the tile by the recirculatory effects of the combustion gases. This can lead to tile over-heating, particularly at the upstream edge where the absence of such holes has the effect of leaving part of the tile exposed to the combustion gases, and also at the downstream edge where the tendency for the film to become detached is greatest.

A further problem associated with high temperature rise combustors is nozzle guide vane platform over-heating. Typically the nozzle guide vanes are mounted at the combustor exit in such a manner that the upstream platform edges are exposed to the full effects of the combustion process. The platform surfaces are generally provided with a plurality of film cooling holes for platform cooling, but for manufacturing and integrity reasons there is an absence of such holes at the platform edges and therefore a limit to the temperature which they can withstand.

The present invention therefore has for a first objective improvements to the cooling of heat resistant sidewall tiles, and as a second objective improvements to the cooling of a nozzle guide vane platforms adjacent such tiles.

According to the invention there is provided a cooling arrangement for heat resistant tiles in a gas turbine combustor, comprising a plurality of tiles arranged in a closely spaced contiguous relationship, the tiles being provided with effusion means for promoting an effusion cooling film flow across an exposed face of the tiles, the effusion means comprising at least one row of effusion holes positioned towards the edge of a tile for promoting an effusion film across an adjacent edge of a neighbouring component.

Preferably there is at least one row of effusion holes formed towards a downstream edge of the tile, and at least one further row of effusion holes formed towards an upstream edge of the tile.

The effusion holes maybe formed in rows substantially parallel to an edge of the tile.

Preferably the effusion holes are angled relative to the tile surface in the downstream direction of the tile.

The arrangement may be such that a final row of cooling holes positioned towards the downstream edge of a tile are adapted to promote a film of cooling air across the upstream edge of a neighbouring tile.

The final row of tiles in the downstream direction of the combustor maybe provided with at least one row of effusion holes which are arranged to promote a film of cooling air across the platforms of an array of combustor outlet guide vanes.

The invention will now be described in greater detail, by way of example only, with reference to the accompanying drawings , in which:

Figure 1 is a sectioned side view of a gas turbine engine combustor having a heat resistant bulkhead liner and a pair of heat resistant sidewall liners,

Figure 2 is a detailed view of the combustor of Figure 1, in the region A, illustrating a first embodiment of the invention,

Figure 3 is a detailed view of the combustor of Figure 1, in the upstream region B, illustrating a second embodiment of the invention, and

Figure 4 is a detailed view of the combustor of Figure 1, in the downstream region C, illustrating a third embodiment of the invention,

Referring now to the drawings, in Figure 1 there is shown, in side section view, a gas turbine engine annular

combustor 10 surrounded by a generally cylindrical section of engine casing 12 which is coaxial with the combustor about the engine's longitudinal axis 14. The remaining engine detail, such as elements of the compressor and turbine which lie adjacent the combustor are omitted for clarity.

The combustor is of generally conventional configuration and comprises a pair of radially spaced inner and outer annular sidewalls walls 16 and 18 which are connected at their upstream ends by means of an aerodynamically shaped combustor head portion 20. The sidewalls are further connected by means of an annular bulkhead 22 which extends between the sidewalls 16 and 18 to provide an upstream air entry plenum 24 and a downstream combustion chamber region 26. The combustor shown is of the type configured for low emission staged operation and includes both inner and outer radial combustion zones, 28 and 30 respectively. The inner and outer zones 28 and 30 are separated by means of an annular centre body 32 which extends in a generally axial direction from the annular bulkhead structure 22 towards the combustor exit 34.

In use air from an upstream compressor (not shown, but to the left of the drawing) enters the plenum chamber 24 through a plurality of inlet apertures formed in the domed shaped head 20, and exits the plenum through a plurality of air spray type fuel delivery nozzles 36 suspended from the engine casing 12. The nozzles 36 are mounted in pairs on radially extending fuel delivery arms 38 which are circumferentially spaced around the combustor head 20 for even distribution. The nozzles are positioned in corresponding fuel nozzle apertures 40 formed in the combustor bulkhead for discharge to the combustion chamber during operation.

An annular seal 42 is positioned between each of the nozzles 36 and the bulkhead apertures 40 to prevent leakage of high pressure combustion air. The seals are slidably mounted with respect to the bulkhead to allow limited radial and axial movement of the nozzles 36 relative to the bulkhead structure. This mounting arrangement provides for unrestrained thermal expansion of the combustor relative to the fuel supply nozzles 36, and as such prevents any unnecessary loading of the components due to differential thermal expansion.

A pair of radially spaced protective heatshield liners 44 are mounted on the downstream face of the bulkhead 22 to provide thermal shielding from combustion temperatures. Each of the heatshields 44 has an annular configuration made up of a plurality of abutting heatshield or tile segments 46. The segments, which are of substantially identical form, extend both radially towards the centre body 32 and a respective one of the combustor walls 16 and 18, and circumferentially towards adjacent segments to define a fully annular shield. The tile segments are provided with a fuel nozzle aperture 48 for receiving a fuel supply nozzle 36. The fuel nozzle aperture is surrounded by an annular flange 50 which provides for location of the tile on the bulkhead structure.

The inner and outer combustor walls are each provided with an internal heat resistant liner 68 made up of a plurality of heat resistant tile segments 70. The tile segments 70 are arranged row by row, in a contiguous manner, on each of the internal wall surfaces. The inner and outer liners each comprise four rows of similar, but not identical, tile segments 70 which extend circumferentially to form a fully annular liner between the combustor bulkhead 22 and exit 34.

With reference now to Figure 2, the tiles are spaced a short distance from the combustor walls by flanges integrally formed on the underside of the tiles. The flanges are formed around the side edges so that they define an enclosed cavity 78 between the tile and combustor wall. Each tile includes a pair of axially spaced side edge flanges 76a and 76b which respectively define the upstream and downstream extremities of the tile, and a pair of circumferentially spaced side edge flanges (not shown) which define the respective circumferential extremities of the tile.

The tiles are secured to the combustor walls by retaining studs 80 formed on the rear face of the tiles. The studs are mounted in bosses 82 on the underside of the tile in the region enclosed by the side edge flanges 76a, 76b. The studs are offset axially towards the upstream flange 76a so as to provide increased clamping at the upstream edge.

As shown, the upstream flange 76a is shaped to clamp the downstream flange 76b of an adjacent tile in the liner assembly. The upstream flange is shaped such that it defines an inwardly facing lip at the upstream edge of the tile. The downstream flange has a generally L-shaped configuration which defines an inwardly extending portion 84 and a wall contacting portion 86. The upstream flange of one tile engages the the wall contacting portion 86 of the neighbouring tile to form a sealed joint. The whole assembly is held together by the lock nuts 88 which hold the overlapping portions in sealing engagement with the combustor wall.

The combustor walls are each formed with a plurality of air entry apertures for the supply of cooling air to the tile cavities for tile cooling purposes.

In accordance with the invention the combustor wall tiles are each provided with a plurality of effusion film cooling holes 90 for promoting an effusion film cooling flow across the exposed face 92 of the tiles. The holes are arranged in rows positioned towards the upstream and downstream edges of the tile. Preferably the holes are disposed in rows parallel to the edges of the tile. The holes are angled with respect to the tile so that they promote a flow of film cooling air in the downstream direction of the tile, to the right of the drawing in Figure 2.

In Figure 2 the tiles are provided with two rows of circumferentially spaced cooling holes 94a and 94b at the upstream end, and three rows 94c, 94d and 94e at the downstream end. The upstream rows 94a,94b are spaced a short distance from the upstream flange 76a for maximum cooling effect. Two of the downstream rows 94c and 94d are similarly spaced from the downstream flange 76b, but the third row 94e is formed in the inwardly facing portion 84 of the flange. The cooling holes which define the two upstream and two downstream rows 94a-d are inclined with respect to the tile surface by substantially equal amounts. Preferably these rows are angled 25 degrees to the tile surface 92, but other angles may be selected if desired. The tiles forming the final row of cooling holes have a shallower angle with respect to the main tile surface. In the example shown the holes in row 94e are formed at 15 degrees to the tile surface 92. This angle is determined by the shape of the adjoining side edge. The angle is such that the holes promote a parallel flow of film cooling air over the upstream edge of the neighbouring tile. This flow ensures that there is a continuous film of cooling air between adjacent tiles, and also between the forward extremity and first row of cooling holes 94a of the

tiles. The cooling holes of the final row 94e are positioned towards the proximal end of the downstream flange 76b so that the exiting flow protects the uncooled surface of the neighbouring tile. Preferably this upstream region of the tile tapers towards the adjoining downstream edge of the neighbouring tile, and preferably by an amount equal to the angle of the final row of cooling holes. The taper assists the formation of a film over the joint and the uncooled tile surface forward of the first cooling hole row 94a.

It will be appreciated that in the event of the film becoming detached at the downstream edge, the film will quickly re-establish. The film will be rejuvenated almost instantaneously by the cooling air exiting the downstream rows 94c-e.

With reference to Figure 3, in a second embodiment of the invention the inner and outer bulkhead tile segments 46 are provided with a like plurality of effusion film cooling holes 96 for promoting an effusion film cooling flow over the exposed heatshield face. The bulkhead tiles 46 are spaced a short distance from the bulkhead in a similar manner to the sidewall tiles to create a series of under tile cavities 98. The cavities are sealed in a similar respect by inwardly facing flanges 100 positioned around the tile periphery. Cooling air apertures 102 are formed in the bulkhead for the passage of high pressure cooling air from the plenum 24 to the under tile cavities 98.

A final row of effusion film cooling holes is formed in the the radially inner heatshield tiles 46 close to the inner side edge, and in the radially outer tiles (not shown in Figure 3) close to the outer side edge. In both cases the cooling holes are angled relative to the tile

surface to provide an effusion film flow over the exposed upstream edge of the neighbouring first row of sidewall tiles 70. Preferably the bulkhead and sidewall tiles are arranged as close to one another as possible so as to maximise the cooling effect of the effusion film as it sheds off the bulkhead tiles onto the sidewall tiles.

With reference to Figure 4, the tiles forming the final row at the downstream end of the combustor are similarly provided with effusion film cooling holes for promoting an effusion film cooling flow over the upstream platform edges 104 of an adjacent array of nozzle guide vanes 106. Three rows of effusion cooling holes are arranged at the downstream end of these tiles in an identical manner to the Figure 2 embodiment. The rows are identified by the same reference numerals in the two embodiments.

The effusion holes function in an identical manner to the holes of the Figure 2 embodiment, but this time the holes at the downstream edge of the tile promote an effusion film over the exposed upstream edge of the neighbouring vane platforms.

CLAIMS

1 A cooling arrangement for heat resistant tiles in a gas turbine combustor, comprising a plurality of tiles arranged in a closely spaced contiguous relationship, the tiles being provided with effusion means for promoting an effusion cooling film flow across an exposed face of the tiles, the effusion means comprising at least one row of effusion holes positioned towards the edge of a tile for promoting an effusion film across an adjacent edge of a neighbouring component.

2 A cooling arrangement as claimed in claim 1 wherein there is at least one row of effusion holes formed towards a downstream edge of the tile.

3 A cooling arrangement as claimed in claim 1 or 2 wherein there is at least one further row of effusion holes formed towards an upstream edge of the tile.

4 A cooling arrangement as claimed in claims 1 to 3 wherein the effusion holes are formed in rows substantially parallel to an edge of the tile.

5 A cooling arrangement as claimed in claims 1 to 4 wherein the effusion holes are angled relative to the tile surface in the downstream direction of the tile.

6 A cooling arrangement as claimed in any preceding claim wherein a final row of cooling holes positioned towards the downstream edge of a tile are adapted to promote a film of cooling air across the

upstream edge of a neighbouring tile.

7 A cooling arrangement as claimed in any preceding claim wherein the final row of tiles in the downstream direction of the combustor are provided with at least one row of effusion holes which are arranged to promote a film of cooling air across the platforms of an array of combustor outlet guide vanes.

8 A cooling arrangement substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No:	GB 9503580.4
Claims searched:	1-8
Examiner:	Robert L Williams
Date of search:	30 May 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): F4T (TAR4)

Int Cl (Ed.6): F02C 7/16,7/18 F23R 3/00,3/06

Other: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO 92/16798 A1	A Pidcock et al	1-6
X	US 5,079,915	A L P Veau (note figs 1,2,3 and 5)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.